DIVERSION EFFECTS ON FISH POPULATIONS

CALFED Alternative Evaluation for Central Valley Salmon Survival within the Delta

INTRODUCTION

This report describes an analysis performed by a subcommittee on chinook salmon. The subcommittee's charge was to evaluate variations in the survival of salmon within the Delta for each of several scenarios being considered in the CALFED Program. No Action, Common Programs, and Alternatives 1, 2 and 3 were the scenarios and they were evaluated in relation to existing conditions. The evaluation was based on one operations study for each scenario. Because variations in operations could result in considerable differences in effects on salmon, the analysis produces only a first approximation of potential differences among scenarios.

Analysis of survival throughout the entire Sacramento-San Joaquin system and the ocean would be necessary to evaluate the overall impact of the CALFED alternatives on chinook populations. Evaluation of effects on survival upstream from the Delta are particularly important for CALFED's Ecosystem Restoration and Water Quality programs. The within-Delta analysis is sufficient to describe the full effects on salmon of the alternative ways of transferring water across the Delta that are being considered by the CALFED program.

The subcommittee prepared separate analyses for chinook salmon from the Sacramento and San Joaquin systems, because of their different use of the estuary. Use by salmon from the San Joaquin is less complex, as only one race, fall run, is involved. For the Sacramento system, four races are involved, each having a distinctive use of the estuary, and collectively involving significant use of the estuary in every month except July. (In August, estuary use is limited to upstream migration by adults, and no adverse effects were identified by the subcommittee.)

Two of the races, the Sacramento winter and spring runs, are receiving protection under endangered species laws and thus require special consideration in making management decisions. At this stage, the subcommittee's analysis integrates effects over all runs.

The subcommittee first analyzed the effects (by month) of parameters expected to influence salmon survival in the Delta. The subcommittee used the results of this analysis to answer a series of questions posed by CALFED. This report includes both a description of the subcommittee's analysis and answers to CALFED's questions.

The subcommittee was co-chaired by Patricia Brandes, U. S. Fish and Wildlife Service and Sheila Greene, Department of Water Resources. Other biologists participating fully throughout the analysis were Serge Birk, Central Valley Project Water Association, Pete Chadwick, Department of Fish and Game, Karl Halupka, U. S. National Marine Fisheries Service, Jim Starr, Department of Fish and Game, and Jim White, Department of Fish and Game.

METHODS

The analysis consisted of creating a matrix for each scenario. All matrices had columns for each month and rows for each parameter expected to affect salmon survival (Appendices 1 and 2). Each matrix cell was assigned a integer value reflecting the relative magnitude of adverse or beneficial effects of each parameter on the entire population in each month. Integer values initially ranged from -3 to +3, but for matrices other than Existing Conditions, a few cells were assigned values outside the -3 to +3 range to maintain a consistent assessment of effect magnitude relative to Existing Conditions. Scoring was done first for Existing Conditions, and then sequentially for No Action, Common Programs, and Alternatives 1, 2, and 3. For Alternatives 1, 2, and 3, separate analyses were conducted for the alternative with no additional storage and for the alternative with the maximum amount of storage being considered by CALFED.

The primary goal of scoring the Existing Condition matrix was to obtain a set of consensus values that accurately described present conditions. These values subsequently served as a baseline for comparison with other scenarios. The subcommittee assigned Existing Condition values judged reasonable in relation to limiting factors, without making any attempt to relate values to some specific set of historical conditions. The committee has not attempted to define "recovery", "restoration", or any other potential CALFED goal.

Evaluations considered both the magnitude of effect for each variable, and the proportion of the population present, in judging the value for each cell in the matrix. A parameter causing a small change on a large fraction of the population, for example, would have the same population effect as one causing a large change on a small fraction of the population, and thus receive the same score in the evaluation.

Evaluations were based on best professional judgements of the degree to which each parameter affects salmon survival. The judgements considered empirical relationships between parameters and survival, where such relationships were available. Evaluations were based on qualitative assessments of the degree to which water operations, water management facilities, and biological factors affect the population.

Evaluations are based on a single operations study for each scenario. The specific CALFED operations studies used for each scenario were: Existing Conditions - 558, No Action - 516, Alternative 1 without storage - 518, Alternative 1 with storage - 609, Alternative 2 without storage - 528, Alternative 2 with storage - 532a, Alternative 3 without storage - 595, and Alternative 3 with storage - 567. Flow changes associated with the Common Programs were evaluated by comparing flows below Hood and at Rio Vista in study 518 to flows in studies 516 and 518, and from tables in Appendix E of the 19 May 1998, draft modeling studies. Analyses were based on monthly flows at selected locations in the Delta, averaged over all years and averaged over selected dry and critical years. Despite recognition of the pitfalls associated with using average values, the subcommittee had insufficient time to explore fully or to consider scoring the full range of annual variability.

Evaluations for the Sacramento system considered each of the four races of chinook and their occurrence in the Delta as fry, smolts, or yearlings. The subcommittee attempted to integrate effects over the life stages of each race in determining values for each matrix cell. The evaluation also considered effects on returning adults migrating through the Delta.

One of the parameters included in the matrices is Toxics. Acute and chronic toxic effects have been identified in the Delta, but results of standard toxicity bioassays have not been related directly to salmon in ways that the subcommittee felt competent to judge. Such effects would be expected to change due to the CALFED Water Quality Program, but that program is not yet described with sufficient specificity to judge how it might affect salmon. Water quality differences may also occur among alternatives due to differences in dilution in different areas of the Delta, or due to changes in the toxic constituents delivered to the Delta associated with changes in proportional flow from the Sacramento and San Joaquin rivers. The subcommittee did not feel competent to offer judgements on any of these aspects of toxicity.

For each matrix, values for each parameter were summed over months to estimate an overall annual consequence for each parameter. Upon examining annual totals for some parameters or groups of parameters, the subcommittee concluded that some were not weighted properly in relation to other parameters. In such cases, the subcommittee divided or multiplied by a constant to provide the proper relationship among parameters or groups of parameters. Only the annual totals were weighted in that fashion, so the reader needs to use caution in reaching conclusions based on comparison of monthly estimates. The monthly estimates would also need to be weighted for comparisons among parameters to be valid.

For the San Joaquin system, weighting among parameters was incorporated directly as cells were assigned values in the matrix.

RESULTS

Chinook Salmon From The Sacramento System

Existing Conditions: To clarify and summarize the results of the matrix analysis, parameters were grouped into categories representing different types of effects (Tables 1 and 2). One group concerns Entrainment Losses. These are estimates of losses occurring immediately in the vicinity of export diversions, which in this case are the CVP and SWP diversions in the south Delta. The overall estimate of Entrainment Losses is based primarily on the Percent Exposed parameter. When the sum of the other three entrainment related parameters (Screen efficiency/Predation, Trucking/Handling, and Clifton Court Forebay Loss) exceeded 3, the

Percent Exposed parameter was adjusted by -1 to reflect increased severity of Entrainment Losses.

The other grouping is for Interior-Delta Survival. This parameter reflects mortality of juvenile Sacramento system salmon diverted from the Sacramento River into the Mokelumne and San Joaquin portions of the Delta, exclusive of Entrainment Losses. It is the sum of Flow Distribution, Delta Cross Channel, Predation, Temperature, and Salinity. Flow Distribution is based on flows in Old and Middle Rivers, which connect the San Joaquin River to the export pumps, and flows in the San Joaquin River downstream of the Mokelumne. The subcommittee considers this parameter to be a surrogate for effects associated with flow and olfactory cues, which are believed to be related to survival indirectly through mechanisms such as influencing the duration of emigration. This statement is based on general knowledge of salmon biology and the subcommittee recognizes that experimental evidence does not exist to identify the specific causes of mortality in the Delta.

The subcommittee made separate estimates for the five parameters under Interior-Delta Survival to reflect some knowledge of the independent effects of individual parameters, but the subcommittee believes the overall estimate has a stronger factual basis than the individual components. That belief derives primarily from extensive experiments that indicate survival of salmon diverted off the Sacramento River into the interior Delta is one third or less of survival of salmon remaining in the Sacramento River (Table 3). The proportion of salmon actually salvaged at the CVP/SWP fish screens in the south Delta indicates that most of the decrease in survival is due to what is characterized in this analysis as Interior-Delta Survival, rather than to Entrainment Losses. However, the experiments referred to here have not identified the specific causes of the decreased survival.

Compilation of the summary tables prompted the subcommittee to compare and weight the effects of different parameters. When the subcommittee compared the aggregated scores for Entrainment Losses (-20) to the score for Interior-Delta Survival (-30), the subcommittee concluded that this reflects an overweighting of Entrainment Losses (Table 1). The subcommittee concluded that dividing Entrainment Losses by 4 would bring them roughly into balance with empirical evidence on the relative magnitude of mortality from the two sources. Entrainment Losses in all Sacramento system matrices were weighted in this fashion.

Another weighting disparity was identified for the Sacramento system when all matrices were completed. This disparity involved the relative magnitudes of Interior-Delta Survival and Flow below Hood in the Sacramento River. The subcommittee concluded that Flow Below Hood should be multiplied by 2 to make the total scores for that parameter similar in range to the total scores for Interior-Delta Survival. A justification for weighting survival in the Sacramento River and in the Interior Delta nearly the same is that about four times as many salmon remain in the Sacramento River with the Delta Cross Channel gates closed as are diverted into the Delta, but the survival rate of juvenile salmon diverted into the Interior Delta is reduced to one third or less of the rate for fish that remain in the Sacramento River (Table 3).

In summary, Existing Conditions were estimated to have negative impacts primarily due to decreased Interior-Delta Survival and Entrainment Losses, with both being substantial in all months except July and August.

No Action- The subcommittee concluded that the only important difference in comparison to Existing Conditions was due to a decrease in flows of about 10% annually. That translated into small increases in Entrainment Losses in January and February and Interior-Delta Survival decreases in December and January (Table 1).

Common Programs- The Common Programs judged to have some effect on survival of Sacramento salmon are the flow augmentation, wetland and riparian restoration (which translated into decreased predation, more extensive shallow water habitat, and enhanced food supply in the analysis), and agricultural diversion screening components of the Ecosystem Restoration Program (Table 1). Flow augmentation of about 5% is estimated to occur in March and May, which is marginal in the Delta in relation to the effects being judged. It is reflected by an increased score in the matrix for Flow Below Hood during May. Screens on Delta agricultural diversions are estimated to reduce existing impacts in April, May, and June.

The subcommittee feels that the relative effects of wetland and riparian restoration programs are difficult to judge. Where these habitats are available, they are utilized directly by young salmon as rearing habitat, and both terrestrial and aquatic foods produced in these habitats are utilized by both rearing and migrating salmon. These habitats also would be likely to increase the abundance of predators, but most biologists agree that some net benefits will occur for salmon. The subcommittee is not aware of experimental evidence to estimate the magnitude of such benefits. The Ecosystem Restoration Program proposes moderate increases in existing habitat in the Delta. It is not clear, however, how restored habitat will be distributed. The subcommittee believes that if the habitat were concentrated in migration corridors for salmon, benefits would likely be greater than those estimated by the subcommittee. At this point, the subcommittee's conclusions are that restored habitat would provide modest rearing benefits, primarily from December through March, food supply benefits from December through May, and reduced in-Delta predation from March through May.

Alternative 1- The subcommittee concludes that the primary changes in relation to the Common Programs would be in Entrainment Losses and Interior-Delta Survival (Table 1). The new fish screens at the intake to Clifton Court Forebay for both the CVP and SWP would markedly improve screen efficiencies and eliminate losses now occurring in Clifton Court Forebay. For Alternative 1 with storage, this benefit would be offset to some degree due to increased exports and greater exposure of salmon to the screens, primarily in December through March. The increased exports with storage were also estimated to decrease Interior-Delta Survival from October through March.

Alternative 2- Several substantial changes would occur with Alternative 2 (Table 1). Entrainment Losses would increase. This would result from the fraction of the population exposed to the fish screens being substantially greater, due to the combination of exposure to the new diversion at Hood and continued exposure to diversions in the south Delta. A larger fraction of the salmon would be diverted into the interior Delta, because the fraction of water and fish diverted through Georgiana Slough increases as flow decreases in the Sacramento River, and such flow decreases would occur with the Hood diversion. The fraction of those salmon reaching the south Delta screens would be reduced, however, because a smaller fraction of the water diverted into Georgiana Slough would go to the south Delta diversions. Exposure to the fish screens would be further increased in Alternative 2 with storage.

Another adverse effect would be the reduction in flow below Hood in the Sacramento River. The subcommittee expects that this would decrease survival from September through June, with the greatest reductions occurring when the greatest fraction of the flow is being diverted at Hood and when the flows are the lowest.

Another adverse effect is the need to pass adult salmon migrating upstream through the San Joaquin - Mokelumne route to the Sacramento River. These fish would have to pass the Hood fish screen and pumping plant. Although a bypass facility would be built, it seems unlikely that it would fully alleviate new impacts on the adult population.

On the positive side, Alternative 2 would improve Interior-Delta Survival for salmon smolts diverted through Georgiana Slough, due to more favorable flow distribution in the San Joaquin River and the avoidance of any need to open the Delta Cross Channel gates.

Alternative 3- This Alternative would not have the adult salmon passage problem at the Hood fish screens and pumping plant as would occur with Alternative 2. Otherwise the changes would parallel those for Alternative 2.

Entrainment losses would be increased (Table 1) for the same reasons described for Alternative 2, but the increases would be less than in Alternative 2, because exports from the south Delta would be reduced by about 80% and water diverted through Georgiana Slough would be distributed more favorably.

Survival in the Sacramento River below Hood would be reduced essentially the same amount as for Alternative 2.

Interior-Delta Survival would be even better than for Alternative 2, due to better flow distribution in the San Joaquin River.

Chinook Salmon from the San Joaquin System

Existing Conditions- Salmon from the San Joaquin system use the Delta for a smaller portion of the year than salmon from the Sacramento system (Appendix 2). Adults migrate upstream in the

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fall, some fry move downstream in January and February to rear in the Delta, and most of the young migrate downstream as smolts from March through June.

Entrainment Losses in the south Delta are controlled by the same parameters that control Entrainment Losses for salmon from the Sacramento, but the proportion of the population exposed to the screens is much greater because the screens are directly on their migratory pathway.

Interior-Delta Survival is also controlled by similar parameters, except that opening the Delta Cross Channel gates does not have a direct impact, but a barrier at the head of Old River reduces impacts.

Flows at Vernalis replace flows below Hood as a parameter.

Flows during the fall are inadequate for adult attraction and upstream passage. Entrainment Losses, Flows at Vernalis and Interior-Delta Survival are all of concern from January through June. Measures prescribed in the VAMP agreement and the head of Old River barrier partially mitigate adverse conditions in April and May.

No Action- Conditions are similar to Existing Conditions, except for slightly greater Entrainment Losses and poorer Flow Distribution in January and February (Table 2).

Common Programs- As for the Sacramento system, screening Agricultural Diversions and creating wetland and riparian habitat as part of the Ecosystem Restoration Program provide benefits of the same magnitude, and subject to the same caveats as those described for the Sacramento system (Table 2). In addition, flow augmentation provided as part of the Ecosystem Restoration Program are expected to improve conditions in May.

Alternative 1- New screens at the intake to Clifton Court Forebay would substantially reduce Entrainment Losses particularly for Alternative 1 without storage (Table 2). For Alternative 1 with storage, Flow Distribution would become somewhat worse in January through March.

Alternative 2- In comparison to Alternative 1, Interior-Delta Survival would improve due to improved flow distribution downstream from the mouth of the Mokelumne River (Table 2). Otherwise conditions would be similar to those for Alternative 1.

Alternative 3- Reduction in diversions from the south Delta by about 80% would substantially reduce Entrainment Losses and improve Interior-Delta Survival due to Flow Distribution throughout the San Joaquin Delta being even more favorable than in Alternative 2 (Table 2). These changes would improve conditions both for adults migrating downstream and for young rearing in the Delta and migrating downstream.

QUESTIONS

1) Which population or life stages are most sensitive to diversion effects under no action and Alternatives 1, 2, and 3? When and where are they most affected?

Under the No Action Alternative, the San Joaquin basin chinook would be more vulnerable to effects of diversions from the south Delta than Sacramento chinook. All San Joaquin chinook migrate through the south Delta, where they are highly susceptible to direct entrainment, predation in Clifton Court Forebay, and reduced survival associated with unfavorable flow distribution in the southern and central Delta due to channel configuration and south Delta pumping. In comparison, a much smaller proportion of the population of Sacramento chinook are affected by diversions from the south Delta.

Under Alternative 1, San Joaquin and Sacramento chinook Entrainment Losses would be reduced by elimination of Clifton Court Forebay predation, although the altered flow distribution still would affect San Joaquin and Sacramento chinook through prolonged exposure to a variety of mortality sources in the Delta.

Under Alternative 2, the entire population of Sacramento chinook would emigrate past Hood and thus would be exposed to a screened diversion at Hood and to reductions in flow in the Sacramento River downstream from Hood. The San Joaquin and Sacramento chinook that would emigrate through the interior Delta would still be affected by changes in interior-Delta hydrodynamics, although to a lesser degree than in Alternative 1, because of the increased frequency of net downstream flows below the mouth of the Mokelumne River. An effect unique to Alternative 2 would be that adult salmon returning to the Sacramento basin that have been attracted to the Mokelumne River portion of the Delta would be affected adversely due to delays in migration and other impacts at whatever fish passage facility would be constructed at Hood to return these salmon to the Sacramento River.

Under Alternative 3, San Joaquin chinook would benefit from restored flow distribution patterns in the south and central Delta, reduced pumping, and improved screens in the south Delta. Sacramento chinook would still be adversely affected by reduced flows in the Sacramento River. The effect of altered flow distribution on the survival of salmon that enter the interior Delta would be better than for Alternatives 1 or 2.

Juvenile chinook are considered to be at greatest risk to diversion effects due to their need to find their way through the Delta to the ocean. Yearlings and smolts are considered more subject to diversion effects than rearing fry, because they are actively migrating. Fry rearing in the Delta are important to salmon production, especially in wet years, and their survival depends on conditions over a several month period prior to their migrating to the ocean as smolts. During their emigration, they are presumably just as subject to diversion effects as smolts entering the Delta after rearing in upstream areas.

2) Can diversion effects in the South Delta be offset by habitat improvements and other common program actions?

Modest benefits for juvenile chinook were estimated due to enhanced food supply and physiological condition, reduced toxicity, reduced entrainment in small diversions, and more extensive rearing and escape habitat associated with the ERP element of the Common Programs. Considerable uncertainty surrounds how the ERP will be implemented and thus the magnitude of associated benefits. The presumed benefit for salmon from improvement or type conversion of existing habitat is proportionally modest. If the ERP emphasized improving habitat along migration corridors for salmon, benefits would be greater than estimated in this analysis. Increased flows in March and May in the Sacramento River and in May in the San Joaquin River provided by the ERP would provide a minor improvement in chinook survival in the Delta, in addition to the benefits that would be expected upstream of the Delta. Overall, we concluded that the common programs would not provide enough benefits in the Delta to offset fully diversion effects.

The subcommittee did not attempt to estimate benefits to salmon from the Water Quality Program.

3) To what extent can Alternatives 1, 2 and 3 offset diversion effects as presently configured?

Our answer to question 1 answers this question as well.

4) To what extent can diversion effects be offset by modifications to the Alternatives or by operational changes?

The subcommittee has not addressed this question.

5) What is the risk and chances of success of species recovery for each alternative?

The probability for recovery depends on conditions throughout the life history of salmon. Because the subcommittee considered only needs of young and adults in the Delta, the following answers only partially address the question of recovery.

No Action- The No Action scenario continues to rely on closure of the Delta Cross Channel gates from November through June to improve the survival of salmon migrating down the

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Sacramento River. This has a high risk of conflict with water supply operations during low flow periods.

The ongoing efforts of the Ops Group to improve salmon survival under Existing Conditions in the face of limited operational flexibility, and the probable decrease in flexibility over time under the No Action scenario, indicate that very little "recovery" potential would exist under the No Action scenario.

Common Programs- See the answer to Question 2.

Alternative 1- As with the No Action scenario, reliance on closure of the Delta Cross Channel gates would continue.

Experience with fish screen operations in the south Delta indicate a high probability that the benefits expected from improved fish screens would be achieved. Such benefits are limited by the need for continued handling and trucking, but experimental evidence indicates this is less of a risk for salmon than for many other species.

Alternative 1 includes measures such as the Water Use Efficiency and Water Transfer programs, which would somewhat increase flexibility in water supply operations. Thus Alternative 1 offers some potential for shifting diversions to times less detrimental to salmon, but such shifts would be likely to increase impacts on other species, would sometimes interfere with water supply benefits, and probably would not be sufficient to cause major improvements in salmon production.

Overall, Alternative 1 is not likely to result in significant increases in survival for salmon from the Sacramento system.

For the San Joaquin, Alternative 1 would increase salmon survival somewhat, due to the improved structure and location of the fish screens.

Alternative 2- Risks for new screens in the south Delta are the same as described for Alternative 1. Several new risks for salmon from the Sacramento system are inherent in Alternative 2 associated with the diversion at Hood. One is the fish screens themselves. Advances in fish screen design provide good evidence that a successful screen can be built, but all large fish screens have inherent risks. Even the best screen would increase the risk for salmon from the Sacramento system, due to the greater exposure of the population to the screen. Also, the screen and the pumping plant that would accompany it would pose a new risk for adults migrating upstream. Finally, the diversion would reduce flows in the Sacramento River below Hood. The subcommittee recognized considerable uncertainty in the consequences of that reduction, based both on questions about evidence of the effects on survival and about the magnitude of flow reductions that would occur over the range of operating conditions. The subcommittee, however, believes that Alternative 2 would pose risks for salmon from the Sacramento system greater than any other alternative. For salmon from the San Joaquin, Alternative 2 would be intermediate between Alternatives 1 and 3.

Alternative 3- San Joaquin basin chinook have the greatest potential to benefit from Alternative 3, but the improvement may not ensure "recovery". Flows at Vernalis are strongly correlated to population levels of San Joaquin salmon, and although the Alternatives would improve San Joaquin flows as a result of ERP flows, the improvements are expected to be small and affect in-Delta survival little.

The benefits that are most certain are the reduction in entrainment losses associated with the large reduction in diversions from the south Delta. Those benefits would be for both Sacramento and San Joaquin stocks.

Alternative 3 would not have the risk for upstream migrants that Alternative 2 would have. Other risks of the Hood diversion would be essentially the same as those described for Alternative 2.

6) What increment of protection or improvement for fish species will be provided by other programs such as the CVPIA, biological opinions?

The increment of improvement for the various programs is difficult to quantify, but if most of the actions contained within the Anadromous Fish Restoration Plan are implemented, substantial improvement should be achieved. The CALFED program, as it is proposed, would include restoration elements not included in CVPIA and the Biological Opinions.

7) What degree of benefit and impact will the common programs provide?

We estimated that improvement would occur with the common programs. Much of the benefit predicted is due to the creation of additional shallow water habitat of several different types. The effect on salmon is uncertain, largely due to the scarcity of evidence regarding the ecological tradeoffs associated with increasing restored habitat area in an aquatic ecosystem dominated by introduced species. Salmon, particularly presmolts, are likely to use restored habitat. Although the habitat will also be favorable for predators, the increased cover and food supply will increase salmon survival in the opinion of most salmon biologists. Screening Delta diversions and improved Delta water quality are also expected to be beneficial.

8) What are the direct and indirect effects on chinook populations resulting from each Alternative and what is the expected response of the populations to these effects?

The Results section and summary tables included in this report address this question. However, the subcommittee is concerned that some readers may focus on the summarized information without appreciating the imprecision and uncertainties involved. The numbers in the summary tables should be interpreted carefully and are most appropriately used to support broad generalizations such as those offered after the summary tables. Imprecision and uncertainty are involved throughout, and the subcommittee is particularly concerned with Flow Below Hood and Interior-Delta Survival. We did not have adequate time to explore and cite the available evidence to the degree that we would have liked, and even if we had, considerable uncertainty would remain as to both the magnitude of effects and the controlling mechanisms.

The annual sums are useful for gross comparisons among scenarios, but the monthly evaluations are essential for more fully understanding the scenarios and formulating alternative operations.

Table 1

Summary of matrices evaluating the effects in the Delta on chinook salmon from the Sacramento River basin. Alternatives 1, 2, and 3 were evaluated without any new storage and with maximum new storage contemplated by CALFED (results are presented: without/with).

Effects	Existing	No Action	Common	Alt. 1	Alt. 2	Alt. 3
Entrainment Losses	-5	-6	-6	-4 / [illegible]	-7 / -8	-6 / -7
Flow below Hood	-6	-6	-4	-4	-28	-28
Interior-Delta Survival	-30	-32	[illegible]	-25 / -31	[illegible]	[illegible]
Shallow water habitat, food supply & ag diversion screens	-3	-3	+10	+10	+10	+10
Upstream migration of adult salmon	0	0	0	0	-19	0
Total	-44	-47	-25	-23 / -30	-51 / -57	-24 / -25
Change from existing conditions		-3	+19	+21 /+14	-7 / -13	+20 /+19
Change from Common Programs				+2 / -5	-26 / -32	+1 / 0

Table 2

Summary of matrices evaluating the effects in the Delta on chinook salmon from the San Joaquin River basin. Alternatives 1, 2, and 3 were evaluated without any new storage and with maximum new storage contemplated by CALFED (results are presented: without/with).

Effects	Existing	No Action	Common	Alt. 1	Alt. 2	Alt. 3
Entrainment Losses	-12	-13	-13	-7 / -10	-7 / -10	-2 / -2
Vernalis flow	-18	-18	-17	-17	[illegible]	-17
Interior-Delta Survival	-23	-25	-19	-19 / -22	-2[illegible]	+14 /+14
Shallow water habitat, food supply & ag diversion screens	-3	-3	+8	+8	+8	+8
Total	-56	-59	-41	-35 / -41	-18 / -24	+3 / +3
Change from existing conditions		-3	+15	+21 / +15	+38 /+32	+59 /+59
Change from Common Programs				+6 / 0	+23 /+17	+44 /+44

A summary for the Sacramento system (Table 1) is that compared to Existing Conditions the Common Programs would provide a substantial benefit, but some negative consequences would persist. With Alternatives 1 and 3, approximately the same net magnitude of consequences would persist as with the Common Programs, but for quite different reasons. For Alternative 1 there would be little change from the Common Programs for any category of parameters, and for Alternative 3, our estimate of improvements in Interior-Delta Survival would be offset by detriments from flow reductions below Hood. For both Alternatives 2 and 3, the consequences of flow reductions below Hood would vary considerably depending on the magnitude of flow. In high flow periods, effects might be inconsequential, but in low flow periods, survival would probably be less than the approximation of the overall average included in the summary.

A summary for the San Joaquin system (Table 2) is that compared to Existing Conditions the Common Programs would provide benefits similar to those provided for the Sacramento system. As in the Sacramento system, Alternative 1 would provide little change from the Common Programs. For Alternatives 2 and 3 the consequences would be quite different than for the Sacramento system. Alternative 3 would clearly be superior, and Alternative 2 would provide intermediate benefits.

Table 3

Survival indices to Chipps Island for coded wire tagged fall-run smolts and late-fall run yearlings released at Ryde and in Georgiana Slough between 1992 and 1996.

Fall run

Date	Ryde	Georgiana Slough	Ratio (GS/R)
4/6/92	1.36	0.42	0.30
4/14/92	2.14	0.73	0.34
4/27/92	1.67	0.20	0.12
4/14/93	0.41	0.13	0.31
5/10/93	0.86	0.29	0.33
4/12/94	0.20	0.06	0.30
4/25/94	0.18	0.11	0.61
		Mean =	0.33

Late fall

Date	Ryde	Georgiana Slough	Ratio (GS/R)
12/2/93	1.91	0.28	0.14
12/5/94	0.57	0.16	0.28
1/4/95	0.3[illegible]	0.12	0.36
1/10/96	0.66	0.17	0.25
[illegible]*	0.90	0.24	0.27
12/4/97*	0.70	0.03	0.04
		Mean =	0.22

* Preliminary data